

Botulism Among Alaska Natives

The Role of Changing Food Preparation and Consumption Practices

NATHAN SHAFFER, MD, Atlanta, Georgia; ROBERT B. WAINWRIGHT, MD, DTM&H, and JOHN P. MIDDAGH, MD, Anchorage, Alaska; and ROBERT V. TAUXE, MD, MPH, Atlanta, Georgia

Alaska Natives have one of the highest rates of food-borne botulism worldwide. All outbreaks have been associated with the consumption of native foods, but in recent years outbreaks have occurred in previously unaffected areas and have involved new food items. Five botulism outbreaks occurred between 1975 and 1985 in an area of southwestern Alaska without previous confirmed outbreaks and among one ethnic group, the Yupik Eskimo. Of the 5 outbreaks, 3 were associated with fermented beaver tail, a nontraditional native food recently introduced into the region. Preparation techniques vary widely within villages and among ethnic groups. Traditional fermentation techniques have changed over the past 50 years; current preparation methods used by some families and ethnic groups may be more favorable for *Clostridium botulinum* growth. Prevention efforts should be targeted at high-risk subgroups of Alaska Natives who appear to have modified traditional practices and increased their risk of food-borne botulism.

(Shaffer N, Wainwright RB, Middaugh JP, et al: Botulism among Alaska Natives—The role of changing food preparation and consumption practices. West J Med 1990 Oct; 153:390-393)

Alaska Native Americans have one of the highest rates of food-borne botulism in the world. Despite the expectation that outbreaks would decrease with increasing westernization and education campaigns,¹ the annual number of outbreaks has remained relatively constant since the 1970s,² and recent outbreaks in Alaska have occurred in previously unaffected regions.

The epidemiology of Alaska Native botulism is complex, with seasonal, demographic, and food-vehicle differences in the pattern of outbreaks.² Outbreaks associated with fermented fish heads ("stinkheads") and fish eggs ("stink eggs") occur in the summer, while outbreaks associated with fermented whale ("muktuk"), fermented beaver tail ("stinky tail"), and fermented seal flipper occur throughout the year. Most outbreaks have occurred among Eskimos in western Alaska and among Native Americans in the southeast.^{2,3} The extent to which variations in fermented food preparation and consumption practices might account for some of these differences has not been described.

The first confirmed botulism outbreak in the Bristol Bay area of southwestern Alaska occurred in 1975. News of this event spread widely throughout Bristol Bay. Because of concern that the use of plastic containers might favor *Clostridium botulinum* growth, an education campaign was conducted warning of the dangers of using plastic bags to prepare or store fermented foods.¹ After several years without additional outbreaks, four outbreaks occurred in Bristol Bay in 1984 and 1985. Because botulism appeared to be a relatively new phenomenon in this area, we investigated these outbreaks to learn more about the risk factors related to food preparation and consumption practices.

Background

Bristol Bay (104,700 km² [40,425 sq mi]) has a native population of 4,137 (1985 census) Yupik Eskimos, Aleuts, and Athabascan Indians living in villages of 30 to 500 per-

sons (Figure 1). Dillingham, the largest town in the region, has a year-round mixed Alaska Native and white population of 1,500, which increases to 10,000 during the salmon fishing season of June through August.

With the introduction of western conveniences and consumer goods, Alaska Native life-styles have changed dramatically over the past 25 years. The patterns of village life, however, are still largely determined by the seasonal activities of hunting, fishing, and gathering. In summer, most villagers move to temporary fishing camps, where the year's catch is preserved for storage by drying, salting, or freezing. During this time, salmon fish heads and other native foods are traditionally fermented and consumed.

Methods

Surveillance data from the Arctic Investigations Laboratory, Centers for Disease Control, and Alaska Division of Public Health were reviewed. A confirmed outbreak of botulism was defined as a suggestive illness in one or more persons with a common food ingestion and either botulism toxin recovered from serum or food, or *C botulinum* identified in a suspected patient's stool specimen.²

In 1987 we reviewed the original Bristol Bay outbreak investigation reports and interviewed implicated food preparers about their methods of preparation. Standardized questionnaires were administered to community health aides from 20 of the 29 villages in the region, to Alaska Native high school students from four Eskimo villages, and to a sample of food preparers not associated with outbreaks from three affected and three unaffected villages. Questions were asked about the type of fermented foods eaten, the methods of preparation, and changes in practices over time. In addition, open-ended interviews were conducted with elderly Alaska Natives. The χ^2 and Fisher's exact tests were used to compare survey responses. Differences between groups were considered significant at $P \leq .05$ (two-tailed).

From the Enteric Diseases Branch, Centers for Disease Control, Atlanta (Drs Shaffer and Tauxe); Arctic Investigations Laboratory, Centers for Disease Control, Anchorage (Dr Wainwright); and the Epidemiology Office, Division of Public Health, State of Alaska, Anchorage (Dr Middaugh).

Reprint requests to Nathan Shaffer, MD, c/o Enteric Diseases Branch C-09, Centers for Disease Control, Atlanta, GA 30333.

TABLE 1.—Suspected and Confirmed Botulism Outbreaks in Bristol Bay, Alaska, 1947-1986

Date	Village	Ethnic Group	Cases, No.	Sex Female, No.	Deaths, No.	Vehicle	Container	Toxin Type
2/73* . . .	Clark's Point	Yupik	3	3	0	Beaver tail	Plastic	..
3/75† . . .	New Stuyahok	Yupik	3	3	2	Beaver tail	Plastic	A
3/84 . . .	Goodnews Bay	Yupik	1	1	0	Beaver tail	Wood	B
8/84 . . .	Manokotak	Yupik	1	1	0	Seal flipper	Wood	E
7/85 . . .	Ekuk	Yupik	8	8	0	Fish heads	Wood	E
7/85 . . .	Dillingham	Yupik	7	4	0	Beaver tail	Wood	B

*Unconfirmed outbreak.

†First confirmed outbreak in Alaska associated with fermented beaver tails.

Results

Descriptive Epidemiology

Between 1947 and 1972, there were 21 confirmed or suspected Alaska Native botulism outbreaks, a mean of 0.8 outbreaks per year. Most (90%) occurred on the west and southeast coasts. During 1973 to 1986, with active surveillance, 38 confirmed outbreaks were detected (Figure 2), a mean of 2.7 outbreaks per year. While type E botulism is most common, since 1973 types A and B have accounted for 12 (32%) of 38 outbreaks (Figure 2).

Of 38 confirmed outbreaks in Alaska since 1973, 5 (13%) occurred in the Bristol Bay region. In addition to these five confirmed outbreaks, there was one unconfirmed outbreak in Bristol Bay (Table 1). These outbreaks occurred in 6 (33%) of 18 Yupik villages; no outbreaks were reported in the 11 Aleut and Athabascan villages (Figure 1). The confirmed Bristol Bay outbreaks involved 20 cases (range, 1 to 8 per outbreak), 17 (85%) in women. All cases occurred in adults 24 to 69 years of age (median 41.5 years). Two deaths occurred during the 1975 outbreak (case-fatality ratio 10%). The average annual incidence of confirmed botulism cases among Alaska Natives in Bristol Bay during 1973 to 1986 was 3.7 per 10,000 compared with 2.9 per 10,000 statewide.

Three of the five confirmed outbreaks and one unconfirmed outbreak in Bristol Bay were due to fermented beaver tail. No other outbreaks in Alaska were associated with beaver tail. Three of the four beaver tail outbreaks occurred in the early spring, during beaver trapping season.

The Bristol Bay Area Outbreaks

New Stuyahok. In March 1975, signs of acute botulism poisoning developed in three women, ages 42 to 57 years, after they ate fermented beaver tail. Two of the women died of respiratory failure within 24 hours after the symptoms began. The 53-year-old female preparer had wrapped fresh beaver tails in a plastic bag and placed them near a warm stove for more than two weeks.

Goodnews Bay. In March 1984, type B botulism developed in a 30-year-old woman after she ate fermented beaver tail prepared by a 50-year-old woman. Fresh beaver tails were packed in moss and grass in a wooden barrel and set outside for two weeks where it was "warm enough so it wouldn't freeze."

Manokotak. In August 1984, type E botulism developed in a 35-year-old woman after she ate an uncooked, fermented seal flipper. Two seal flippers had been placed in a wooden bucket, covered with moss, and allowed to ferment in the shed house for "about five days in a warm place."

Ekuk. In July 1985, a type E botulism outbreak followed a July 4th feast of fermented salmon fish heads. There were eight confirmed cases, all in women ranging in age from 24 to 69 years. At the time, most of the men in the village were away fishing. The 41-year-old food preparer had been taught to ferment foods by her mother, but had not prepared such foods in many years. As was customary in her family, she placed more than 50 king salmon and red salmon fish heads in a wooden barrel, added fish entrails, and covered the top with a canvas cloth. Instead of placing the

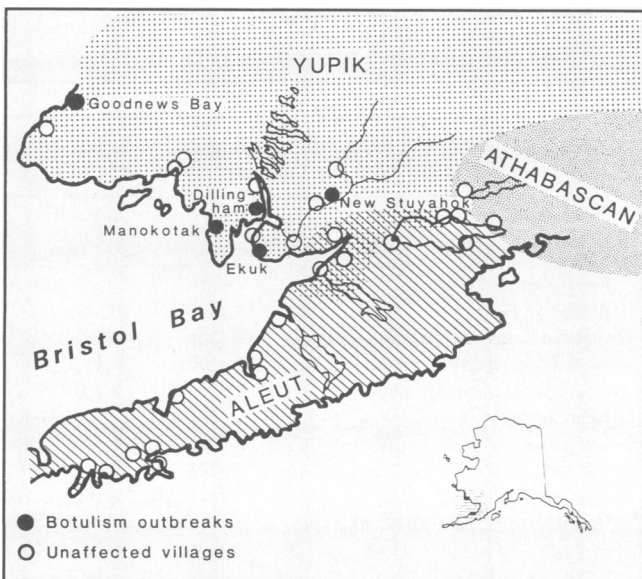


Figure 1.—The map shows the Bristol Bay area of southwestern Alaska, with distribution of ethnic groups and locations of confirmed botulism outbreaks.

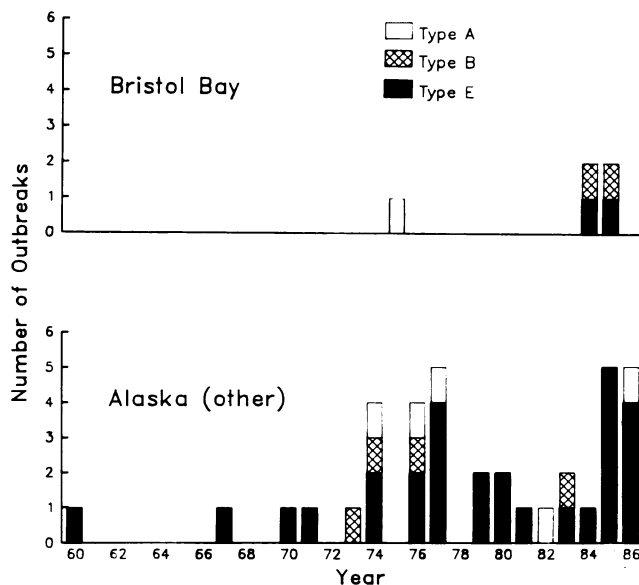


Figure 2.—The graph indicates toxin-confirmed botulism outbreaks in Alaska, by type, 1960-1986 (active surveillance was begun in 1973).

barrel in a pit in the ground for a week as was usually done by her family, she set the barrel out in the open above ground for more than two weeks. In retrospect, she expressed concern that the sun-exposed barrel may have gotten too hot. She recalled having been warned as a child that the sun's rays had a "death meaning" and that fermented foods needed to be kept away from the "killing rays of the sun."

Dillingham. In July 1985, a 59-year-old Eskimo woman prepared fermented beaver tails from frozen tails gathered several months before. The tails were placed in a wooden barrel, covered with moss and water, and set in the drying shed "for about two weeks." At least 15 people ate slices of the beaver tail; symptoms of botulism developed in 7, and 3 had type B toxin detected in their serum. The preparer said she had made beaver tails once or twice a year for 10 years, usually with fresh tails collected during the spring beaver run. She learned to ferment beaver tail from neighbors because her mother and grandmother did not prepare this food.

Surveys of Food Handling Practices

The results of the village health aide survey show that fermented food preparation practices in Bristol Bay vary by village and are most widespread among the Yupik ethnic group (Table 2). Although fermented fish heads are prepared by at least one family in all Yupik villages and most non-Yupik villages, fermented beaver tails were prepared in eight (67%) Yupik villages but in none of the non-Yupik villages ($P < .01$). Currently, most adults were said to eat fermented food in six (50%) Yupik villages but in none of the non-Yupik villages ($P = .04$). Fifteen years ago a majority of families in all Yupik villages and in only half of non-Yupik villages prepared their own fermented foods ($P = .01$).

A survey of 45 Alaska Native high school students from four Yupik villages also showed that the consumption of fermented food was common in that group and varied by family and age. More than half (51%) of families were reported to regularly prepare fermented foods; 71% of parents and 80% of grandparents regularly ate fermented foods, in contrast with 15% of students.

A survey of 24 Yupik food preparers from six villages revealed notable individual differences in preparation practices (Table 3). All prepared fermented fish heads, but only 10 (42%) had prepared beaver tails. Ten prepared fermented foods no more than once a year, 13 prepared them two to five times a year, and 1 prepared them more than five times a year (not shown).

Ethnographic Observations

Local fermentation methods appear to have changed within the living memory of elderly Yupik. Interviews with 12 elderly Yupik indicated that fish heads were traditionally fermented in clay pits dug in the ground; families used the same pit each year. About 50 years ago, large wooden barrels became available and were filled with fish heads and placed into the pits. Recently, many families stopped using these pits and, instead, set the barrels out above ground, usually in the shade. Some preparers now use plastic bags or buckets, and some set these indoors to speed fermentation.

Fermented food practices are distinctly different among the other ethnic groups in Bristol Bay. The Athabascans ferment fish by floating a string of fish heads in the river for one to two weeks. Among the Aleuts, fermented foods were more common a generation ago but even then were not

prepared by all families. Today the few families preparing fermented foods customarily place a wooden barrel filled with fish heads into a pit in the ground in September, at the end of the fishing season; an Aleut reported that they believe that it is too hot in July to make fermented foods.

While Eskimos have long eaten boiled beaver tail stew, fermented beaver tail appears to be a local innovation introduced into several Yupik villages in Bristol Bay in the 1960s. One elderly Eskimo claimed that he had "invented" fermented beaver tail 20 years ago after finding a beaver carcass that had fermented naturally during the spring thaw. Unlike fermented fish heads, fermented beaver tail is not prepared or eaten by the Athabascans or Aleuts, and no traditional method for its preparation could be documented.

Discussion

Fermented foods have caused botulism in several cultures in the circumpolar regions.⁴⁻⁸ In Alaska, while all botulism outbreaks have been associated with fermented or traditional foods consumed by Alaska Natives, recent out-

TABLE 2.—Results of a Village Health Aid Survey: Reported Fermented Food Practices in 20 Bristol Bay Villages*

Characteristic	Yupik Villages (N = 12) No. (%)	Other Villages† (N = 8) No. (%)	P Value‡
Type of fermented food prepared (by at least one family in village)			
Fish heads	12 (100)	6 (75)	NS
Fish eggs	3 (25)	1 (13)	NS
Beaver tail	8 (67)	0 (0)	<.01
Whale flipper	1 (8)	0 (0)	NS
Seal flipper	3 (25)	0 (0)	NS
Most families in village now prepare fermented foods	4 (33)	0 (0)	NS
Most families in village prepared fermented foods 15 yrs ago	12 (100)	4 (50)	.01
Most adults in village eat fermented foods	6 (50)	0 (0)	.04
At least 25% of children in village eat fermented foods	4 (33)	0 (0)	NS
Most children speak English with parents	6 (50)	8 (100)	.04

*Survey asked what percent of families in village followed a given practice.

†5 Aleut and 3 Athabaskan villages.

‡2-Tailed Fisher's exact test (NS = not significant).

TABLE 3.—Fermented Food Preparation Methods: Survey of 24 Food Preparers in 6 Yupik Eskimo Villages

Customary Technique	Fish Heads (N = 24) No. (%)	Beaver Tail (N = 10) No. (%)
Fermentation Chamber		
Hole in ground	3 (13)	0
Wooden barrel in ground	9 (38)	0
Wooden barrel above ground	10 (42)	5 (50)
Plastic bucket above ground	2 (8)	5 (50)
Items Added		
Salt	5 (21)	3 (30)
Fish guts	7 (29)	0
Covered with moss	5 (21)	9 (90)
Duration of Fermentation, wk		
<1	7 (29)	2 (20)
1-2	15 (63)	6 (60)
>2	2 (8)	2 (20)

breaks have occurred in new areas and have been caused by new food vehicles, suggesting that local modifications in the handling of these foods may determine the risk of botulism. In Bristol Bay, we found that fermentation practices vary among ethnic groups and among families in the same village and that traditional fermentation techniques have been modified. Among the Yupik, who experienced all of the local botulism outbreaks, containers set above ground have replaced the traditional covered pit in the ground; time and temperature vary widely. In contrast, the few Aleuts who prepare fermented foods follow traditional techniques that promote slow, low-temperature fermentation, and the Athabascans practice an entirely different method, which also keeps fermentation temperatures low.

Because botulism spores are commonly found in the Alaskan environment,⁹⁻¹¹ fermented foods may carry an irreducible risk of botulism. Changes in fermentation practices appear to favor *C botulinum* growth by providing warmer temperatures and longer incubation times. All reported fermentation times and temperatures in the Bristol Bay outbreaks were compatible with *C botulinum* toxin production. In the laboratory, botulism spores have been shown to be extremely sensitive to environmental conditions. For example, nonproteolytic type B spores produce toxin in 17 days at 5.6°C but in 85 days at 3.3°C.¹² Because the ambient temperature in Bristol Bay in July ranges from 5°C to 17°C, the holes dug into the cool permafrost and used as a fermentation chamber may have provided natural insulation from the summer heat, as do the icy river waters for the Athabascans.

Salt concentrations of 3% to 10% inhibit *C botulinum* growth. In southeast Asia, high salt concentrations protect against bacterial contamination during the fermentation of bean curd and fish,¹³ and, in Japan, *izushi* fermentation is regulated by the salt concentration, incubation time, and temperature.¹⁴ In Bristol Bay, however, salt is rarely used during fermentation.

Most of the Bristol Bay outbreaks were associated with fermented beaver tail, an uncommon, newly introduced fermented food. Thus far, outbreaks of botulism associated with beaver tail have been recognized only in Bristol Bay; it is not known whether fermented beaver tail is eaten in other regions. This cluster of outbreaks suggests that fermented beaver tail may be especially favorable to *C botulinum* growth and that the lack of traditional temperature and time guidelines may make its preparation especially risky.

Although a comprehensive survey of traditional food-eating habits in Bristol Bay was beyond the scope of this study, fermented food consumption appears to be decreasing. However, fermented foods remain popular among cer-

tain groups of Alaska Natives and are prized for their taste and as a symbol of native traditions. In this context, changes in preparation methods in Bristol Bay appear to have increased the risk of botulism by altering traditional time and temperature controls or the type of food itself. These changes may have shifted the delicate cultural and microbiologic balance protecting against this "hazard of the North."¹⁵

An educational campaign directed against fermentation in plastic bags appears to have discouraged this particularly hazardous practice in Bristol Bay. Recent outbreaks indicate the need to promote slow, cold temperature fermentation techniques and to avoid fermenting nontraditional foods, such as beaver tail. Because Alaska Natives are likely to continue consuming fermented foods, further educational efforts emphasizing these principles, along with the continued training of medical providers in the early recognition and treatment of botulism and the continued ability of public health agencies to investigate suspected outbreaks promptly, appear to be the most appropriate control measures to reduce the incidence and morbidity of botulism in Alaska Natives.

REFERENCES

1. Eisenberg MS, Bender TR: Plastic bags and botulism: A new twist to an old hazard of the North. *Alaska Med* 1976; 18:47-49
2. Wainwright RB, Heyward WL, Middaugh JP, et al: Food-borne botulism in Alaska, 1947-1985: Epidemiology and clinical findings. *J Infect Dis* 1988; 157:1158-1162
3. Eisenberg MS, Bender TR: Botulism in Alaska, 1947 through 1974. *JAMA* 1976; 235:35-38
4. Meyer KF: The status of botulism as a world health problem. *Bull WHO* 1956; 15:281-298
5. Dolman CE: Type E botulism, a hazard of the north. *Arctic* 1960; 13:230-256
6. Dolman CE, Iida H: Type E botulism: Its epidemiology, prevention and specific treatment. *Can J Public Health* 1963; 54:293-308
7. Dolman CE: Human botulism in Canada (1919-1973). *Can Med Assoc J* 1974; 110:191-200
8. Hauschild AHW, Gauvreau L: Food-borne botulism in Canada, 1971-84. *Can Med Assoc J* 1985; 133:1141-1146
9. Miller LG, Clark PS, Kunkle GA: Possible origin of *Clostridium botulinum* contamination of Eskimo foods in northwestern Alaska. *Appl Microbiol* 1972; 23:427-428
10. Miller LG: Observations on the distribution and ecology of *Clostridium botulinum* type E in Alaska. *Can J Microbiol* 1975; 21:920-926
11. Houghtby GA, Kaysner CA: Incidence of *Clostridium botulinum* type E in Alaska salmon. *Appl Microbiol* 1969; 18:950-951
12. Eklund MW, Wieder DI, Poysky FT: Outgrowth and toxin production of nonproteolytic type B *Clostridium botulinum* at 3.3 to 5.6°C. *J Bacteriol* 1967; 93:1461-1462
13. Graikoski JT: Microbiology of cured and fermented fish, In Chichester CO, Graham HD (Eds): *Microbial Safety of Fishery Products*. New York, Academic Press, 1975, pp 97-112
14. Nakano W, Kodama E: On the reality of *izushi*, the causal food of botulism, and on its folkloric meaning, In Herzberg M (Ed): *Proceedings of the First U.S.-Japan Conference on Toxic Micro-organisms*, Honolulu, 1968. Washington, DC, Government Printing Office, 1970, pp 388-392